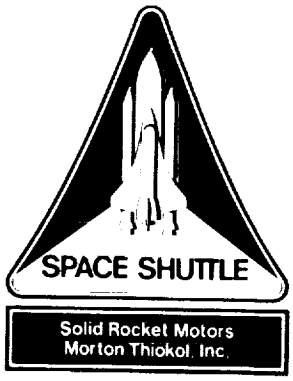

TWR-18445, Rev. A

CONTAMIANTION REMOVAL USING VARIOUS SOLVENTS AND METHODOLOGIES

FINAL REPORT

MAY 1989

Prepared for:

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
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Aerospace Group

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FINAL REPORT

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REVISION DESCRIPTION

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A	June 1989	An Interim Report using TWR-18445 required that Revision A be written for this final report.

CONTENTS

1.0 INTRODUCTION

Critical and non-critical bonding surfaces must be kept free of contamination that may cause potential unbonds. For example, an aft-dome section of an RSRM rocket motor that had been contaminated with hydraulic oil did not appear to be sufficiently cleaned when inspected by the optically stimulated electron emission process (Con Scan) after it had been cleaned using a hand double wipe cleaning method. As a result, current and new cleaning methodologies as well as solvent capability in removing various contaminant materials were reviewed. Testing was performed as outlined in ETP-0335.

Bonding studies were also done to verify that the cleaning methods used in removing contaminants provide an acceptable bonding surface. The initial PAT Scan data which verify the cleanliness of the RSRM cases using optically stimulated electron emission were obtained during the development phases of the monitoring system. Data provided in TWR-18455 Interim Report shows that there are phenomenon which are unexplainable or not understood.

Contaminants were removed from a metal surface with varying degrees of success using the Martin Marietta and double-wipe cleaning methods. PAT Scan data showed that the Martin Marietta cleaning method appeared to remove the contaminants more effectively than the double-wipe cleaning method (Figures 1 and 2). However, the difference in bond strength between a metal surface cleaned using the Martin Marietta cleaning method and the one cleaned using the double-wipe cleaning method is not considered significant when the data are statistically analyzed.

The exceptions to this general pattern are that hydraulic oil appears to be removed more efficiently using the double-wipe cleaning method and the R-78 mold release appears to be more efficiently removed using the Martin Marietta cleaning method.

The fact that there was not a significant difference in bond strength between the two cleaning methods indicates that changing to the Martin Marietta cleaning method is not necessary.

2.0 OBJECTIVES

The objectives of this report are to document:

1. How effective solvents remove contaminants from a metal surface.

2. The comparison of the Martin Marietta hand cleaning method to the double wipe hand cleaning method.

3. How effective the double wipe hand cleaning method is in removing contaminants from a metal surface.

4. How effective the Martin Marietta hand cleaning method is in removing contaminants from a metal surface.

5. Whether significant bond strength differences exist between the Martin Marietta hand solvent cleaning method and the double-wipe hand cleaning method.

3.0 SUMMARY

Each solvent used in this study had various effects on removing the contaminants. There does not appear to be any one solvent that will universally remove all of the contaminants and restore a contaminated surface to an acceptable level of cleanliness, according to CON Scan measurements. It was shown that the contaminants are more effectively removed when they are subjected to a physical force (scrubbing action) rather than by the choice of solvent. Because of the variability seen with each of the solvents on the contaminants, methyl chloroform can continue to be the solvent of choice for hand cleaning operations.

Comparisons of the Martin Marietta cleaning method and the double-wipe cleaning method show that the Martin Marietta cleaning method appears to be more effective in restoring a contaminated surface to an acceptable level of cleanliness than the double-wipe cleaning method when based on PAT Scan readings.

Bonding data, when statistically analyzed, show that a contaminant will significantly reduce the tensile strength of a bonding surface. There was not any significant difference in tensile strength between the Martin Marietta cleaning method and the double-wipe cleaning method after the panels were cleaned, except for the following:

1. The double wipe cleaning method removed hydraulic oil better than the Martin Marietta cleaning method.

2. The Martin Marietta cleaning method removed R-78 better than the double wipe cleaning method.

4.0 CONCLUSIONS

1. Readings obtained during the development and setup phases of the PAT Scan system were questionable in some cases as concerns about the validity of the PAT Scan test results exist.

2. The Martin Marietta solvent cleaning method appears to remove the contaminants more effectively than the double-wipe cleaning method when based on PAT Scan readings.

3. Methyl chloroform solvent can be substituted for the Freon TMC solvent using the Martin Marietta cleaning method.

4. Metal surfaces that are exposed to contaminants will show a significant degradation in tensile strength.

5. The difference in bond strength between a metal surface cleaned using the Martin Marietta cleaning method and one cleaned using the double-wipe cleaning method is not significant except in the following situations:

   a. For removing hydraulic oil, the double wipe method is better than the Martin Marietta cleaning method.

   b. For removing R-78 mold release, the Martin Marietta method is better than the double wipe cleaning method.

   c. Because of the insignificant differences seen between the two cleaning methods, the implementation of the Martin Marietta cleaning method does not seem necessary.

5.0 RECOMMENDATION

1. General Process Instruction GC-1.11, "Hand Cleaning With Solvents" not be updated to include the Martin Marietta solvent cleaning method as an alternate choice to the double-wipe cleaning method based on this study.

6.0 DISCUSSION AND RESULTS

The initial phase of this study plan (ETP-0335) dealt with how effective various solvents can remove contamination from a steel surface. A set of seven D6AC steel plates were grit blasted with zirconium silicate, and PAT Scan readings were taken to determine the level of cleanliness of a grit blasted surface. The panel surfaces were then exposed to one of the following contaminants:

1. Conoco HD-2 Grease
2. Hydraulic Oil
3. Fingerprints
4. MS 122 (Fluorocarbon mold release)
5. Ren Plastic R-78 (Silicone mold release)
6. Mold Wiz 249 (Non-silicone mold release)

After the contaminant was applied to the metal surface, the panels were PAT Scanned and the results recorded. The panels were allowed to sit for 24 hours before being cleaned with one of the following candidates solvents:

1. Methyl Chloroform (TCA)
2. Methyl Ethyl Ketone (MEK)
3. Freon TA
4. 10 percent Freon TA/90 percent methyl chloroform mixture
5. 25 percent Ethanol/75 percent methyl chloroform mixture
6. Toluene
7. Freon TF
8. Freon TMC

A PAT Scan reading of each metal surface was taken after being cleaned to determine the solvent's effectiveness in removing contamination. A final cleaning using the double wipe cleaning method was performed, and PAT Scan readings were taken and recorded. The process was repeated so that each contaminant was exposed to each solvent and to the double wipe solvent cleaning method.

The PAT Scan readings taken after the first solvent exposure to determine the solvent's effectiveness in removing the various contaminants did not follow any set pattern. The general pattern observed was that the organic contaminant material appeared to be removed easier than the mold release contaminants. PAT Scan readings taken after the double wipe cleaning procedure also showed this same general pattern. These preliminary data are recorded in the interim report of this study (TWR-18455).

A general hand solvent cleaning procedure used by Martin Marietta for contaminant removal was tested to see how well it removed the afore-mentioned contaminants. A set of seven panels were grit blasted with zirconium silicate and PAT Scan readings were taken. The contaminant was then applied to the panel surface and PAT Scan readings taken. Each panel was then cleaned using the following procedure:

1. The metal was scrubbed with a clean wiping cloth dampened with Freon TMC.

2. Two hand wipes of the metal surface were made using clean wiping clothes dampened with Freon TMC.

3. The metal surface was scrubbed using an abrasive pad that was soaked with Freon TMC.

4. The metal surface was wiped using a clean wiping cloth dampened with Freon TMC.

After the final wipe with a dampened cloth was completed, PAT Scan readings were taken and recorded. Based on PAT Scan readings, the Martin Marietta cleaning method appears to remove all of the contaminants very effectively.

To further optimize the Martin Marietta cleaning method and its potential use at Morton Thiokol, five solvents were used in a more controlled cleaning operation. Those solvents included:

1. Methyl Chloroform

2. Methyl Ethyl Ketone

3. Ethanol/TCA Mixture

4. Freon TMC

5. MEK/TCA Mixture

A set of six D6AC steel panels and a set of six aluminum panels were grit blasted and PAT Scan readings taken to determine the cleanliness level. The afore-mentioned contaminants were applied in the following amounts:

1. 100 mg/ft^2 of HD-2 grease

2. 100 mg/ft^2 of hydraulic oil

3. 30 mg/ft^2 of MS-122 mold release agent

4. 30 mg/ft^2 of Ren Plastic R-78 mold release agent

5. 30 mg/ft^2 of Mold Wiz 249 mold release agent

PAT Scan readings were taken and recorded. The panels were cleaned using the five listed solvents and PAT Scan readings were taken and recorded. Again, the PAT Scan readings indicated that the Martin Marietta cleaning method was effective in removing the contaminants (Appendices A and B). The PAT Scan readings that were taken on the aluminum panels showed a lot of variation in the readings.

Since most of the PAT Scan work was completed during the early development phase of PAT Scanning, the surface chemistry knowledge of what happens on a grit blasted aluminum surface was limited; as such, the validity of the data is somewhat in question. It was determined that further testing using the aluminum panels would not provide data that are valid. As such, the mold release agents were not tested on the aluminum panels.

The Scotch-Brite pads used in the abrasive scrub of the Martin Marietta cleaning method do not appear to cause an excessive amount of erosion (Table I). Another concern of using the Scotch-Brite pads was the residue left on the panel surface from a methyl chloroform soaked pad. If the metal surface was scrubbed using a dry Scotch-Brite pad the contamination was removed and no detectable residue was found on the metal surface.

A Scotch-Brite pad that had a sponge attached to it was also tested. The sponge material was to aid in keeping the metal surface wet and to help control the solvent from running down the side of the case. The solvent caused the sponge material to deteriorate, leaving more apparent contamination on the metal surface than it was removing. Testing of this pad was then discontinued.

Bonding studies were completed to verify that the Martin Marietta and the double-wipe cleaning methods will provide an acceptably clean bonding surface. The preliminary PAT Scan data obtained from the Martin Marietta cleaning method and the double wipe cleaning method indicate that the choice of solvent is not as large a factor as is the physical scrubbing of the metal surface. As methyl chloroform is the solvent most commonly used in the cleaning operations at Morton Thiokol, it was the solvent of choice to clean the panels in this bonding study.

The use of one-inch tensile buttons was determined not to be practical because of the labor intensive effort required to PAT Scan their surface. Instead, it was suggested that the tensile strength determination be done using beveled tensile buttons on a D6AC steel panel.

A set of six D6AC panels were grit blasted and contaminated with the afore-mentioned contaminants. These panels were cleaned using the Martin Mareitta cleaning method. A set of D6AC panels was also contaminated and cleaned using the double wipe cleaning method. After the panels were cleaned, eight beveled tensile buttons were bonded to the metal surface using EA 934NA.

Tensile adhesion strength was then determined (Table II) and a comparison between the two methods was done. The samples were statistically analyzed to determine if any significant differences in the two methods were observed. The tensile strength data showed a significant degradation when the metal surfaces were exposed to the contaminants. The differences in the tensile strength between the two cleaning methods indicated there is no significant degradation of bond strength. The only exception to this was seen in the case of hydraulic oil, which was more effectively removed by the double wipe method and R-78 which was removed more effectively using the Martin Marietta cleaning method. Otherwise, no significant differences were observed.

7.0 REFERENCES

1. ETP-0335 - "Contamination Removal Using Various Solvents and Methodologies"

2. General Process Instruction GC-1.11, "Hand Cleaning with Solvents", current issue

3. Inter-Office Memo 5523-78-391, "Minutes of Fourth Meeting on MS-122/MS-144 Fluorocarbon Release Agent Contamination Problem"

4. Inter-Office Memo 2432-78-M496, "Mold Release Characteristics of MS-144 Treated With Various Solvents"

5. Inter-Office Memo 2432-78-M450, "Mold Release Characteristics of MS-122 Treated with Various Solvents"

6. Inter-Office Memo 2432-79-M236, "Mold Release Characteristics of Mold Wiz 17121 Treated with Various Solvents"

7. TWR-18445- "Contamination Removal Using Various Solvents and Methodologies" - Interim Report

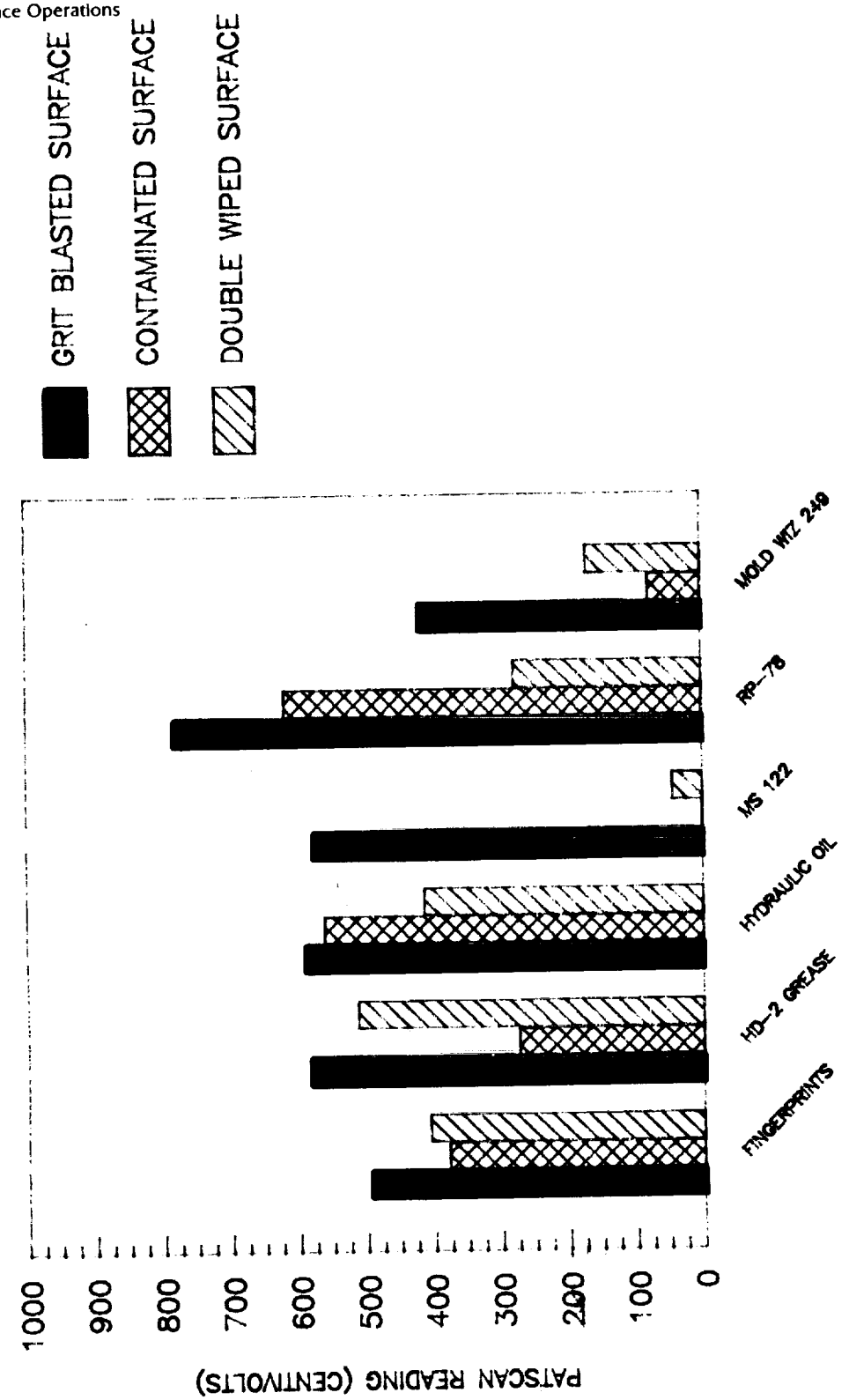


Figure 1. Double Wipe Hand Cleaning Method

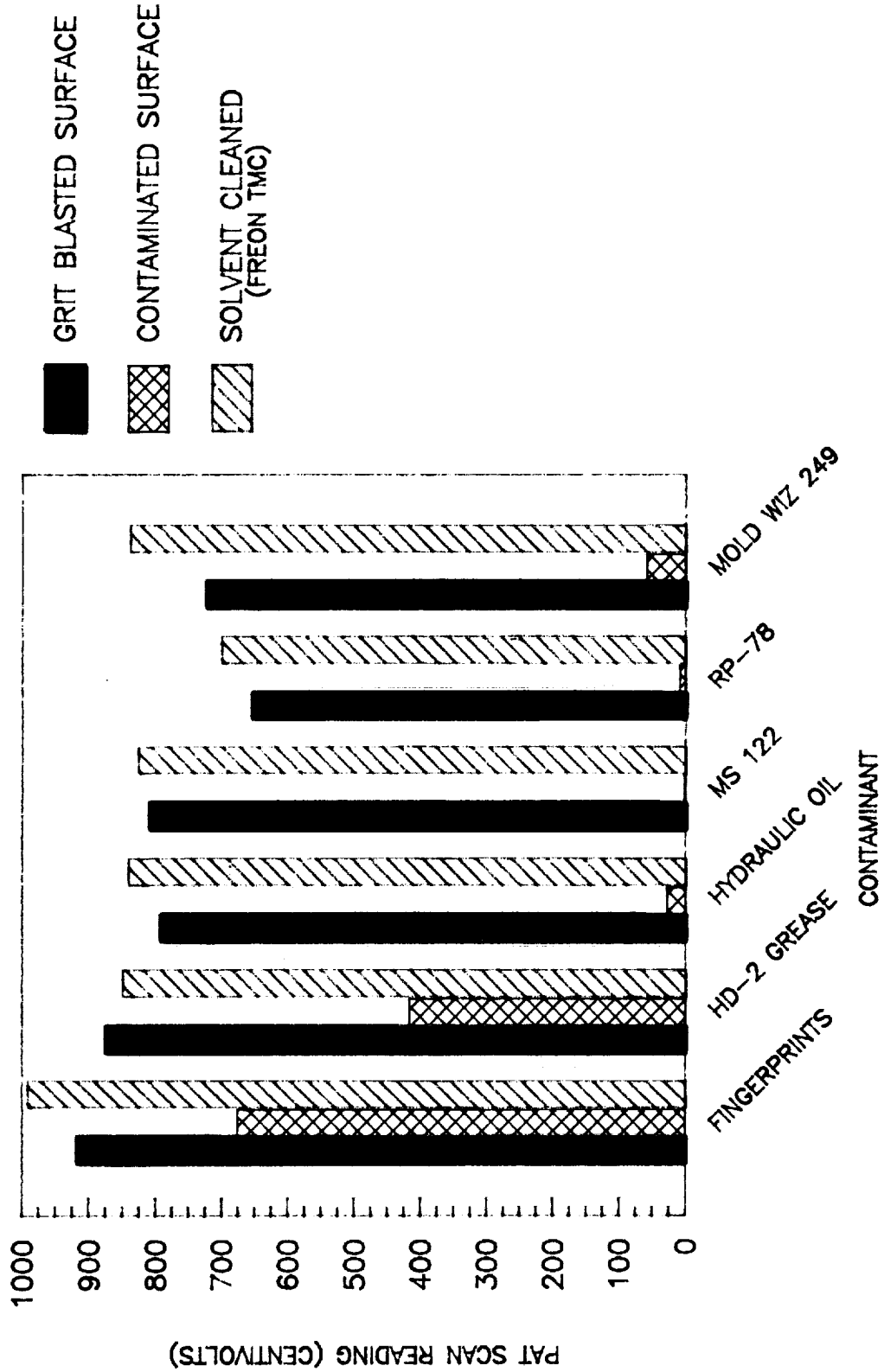


Figure 2. Martin Marietta Solvent Cleaning Method

TABLE I. Scotch-Brite Erosion Test Results

ABRASION DESCRIPTION	TIME ABRADED	COUPON WEIGHTS BEFORE	COUPON WEIGHTS AFTER	WEIGHT LOSS	SQUARE INCH AREA ABRADED	INCHES EROSION
Hand Abrade	1 min	105.8808	105.8703	0.0105	3.97689	0.000020
Dry Pad	2 min	107.2461	107.2293	0.0168	4.01609	0.000032
	3 min	108.0122	107.9986	0.0136	4.04651	0.000026
	4 min	108.1050	108.0879	0.0171	4.07036	0.000033
	5 min	108.2415	108.2144	0.0301	4.04389	0.000058
Hand Abrade	1 min	105.8298	105.8166	0.0132	3.97689	0.000025
Wet Pad	2 min	107.2061	107.876	0.0185	4.01609	0.000036
	3 min	107.9722	107.9474	0.0248	4.04651	0.000048
	4 min	108.0650	108.0340	0.0310	4.07036	0.000059
	5 min	108.1842	108.1558	0.0284	4.04389	0.000055

TABLE II. Tensile Strength Raw Data*

Martin Marietta Cleaning Method

Sample ID	Tensile Strength (psi)	Std Dev	Coeff Of Variation (%)	Failure Mode
Control Surface	3252	489	13	Cohesive - Panel/Button
HD-2 Grease	2335	240	10	Adhesive - Panel Side
Hydraulic Oil	3030	111	4	Cohesive - Button Side
Fingerprints	2648	367	14	Cohesive - Button Side
MS-122	3087	549	18	Cohesive - Button Side
RP-78	2853	455	16	Cohesive - Panel Side
Mold Wiz	1107	116	10	Adhesive - Panel side

*Average of 8 beveled tensile buttons bond with Ea 934NA.

TABLE II. Tensile Strength Raw Data* (Continued)

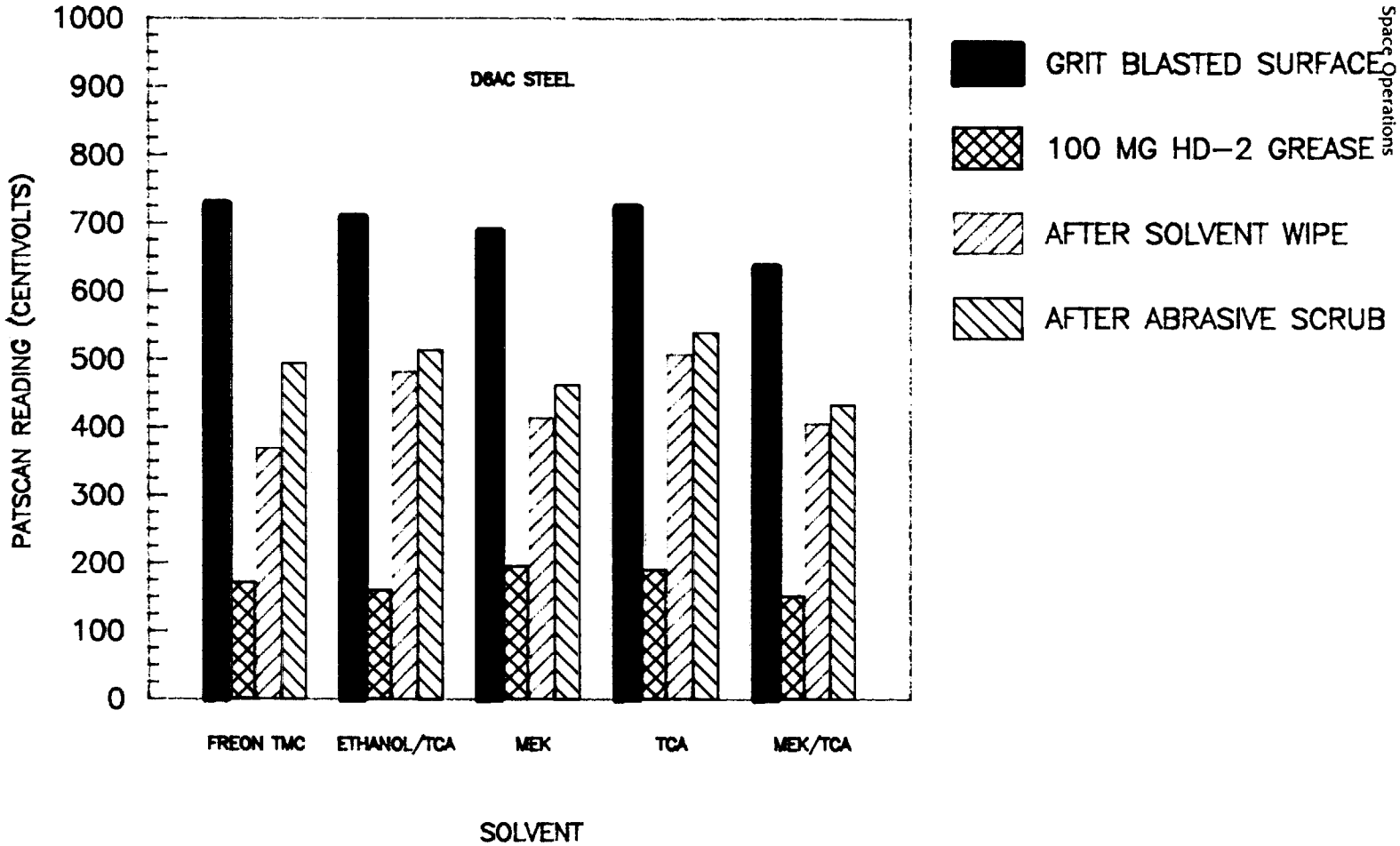
Double-Wipe Cleaning Method

Sample ID	Tensile Strength (psi)	Std Dev	Coeff Of Variation (%)	Failure Mode
Control Surface	3332	662	20	Cohesive - Panel/Button
HD-2 Grease	2291	274	12	Adhesive - Panel Side
Hydraulic Oil	2606	424	16	Cohesive - Button Side
Fingerprints	2209	435	20	Cohesive - Button Side
MS-122	2919	498	17	Cohesive - Button Side
RP-78	2234	352	16	Adhesive - Panel Side
Mold Wiz 249	792	101	13	Adhesive - Panel Side

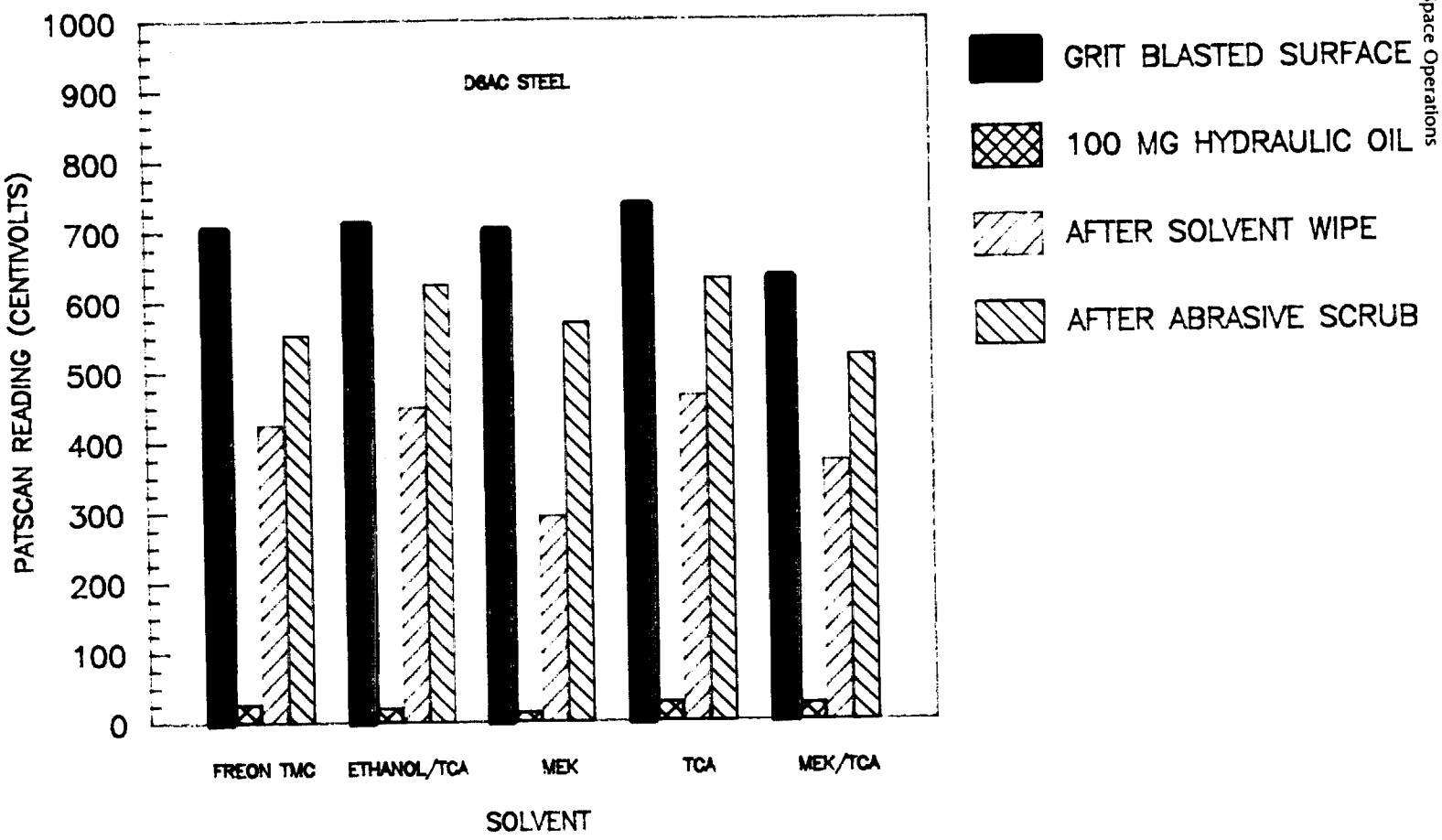
*Average of 8 beveled tensile buttons bonded with EA 934NA.

APPENDIX A

MARTIN MARIETTA CLEANING METHOD - D6AC STEEL

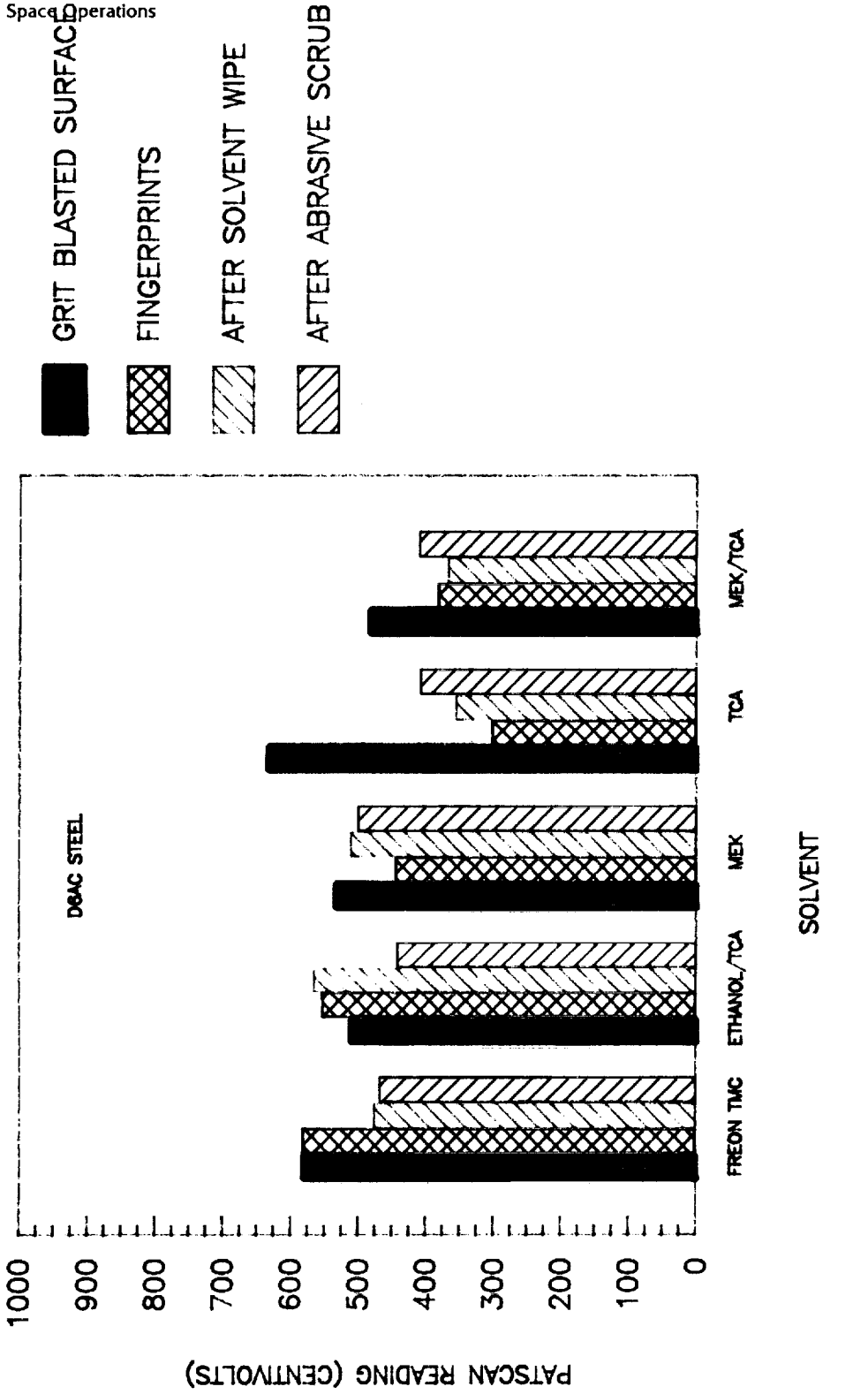


CHEMICAL AND PHYSICAL CHARACTERISTICS OF CONTAMINATION REMOVAL BASED ON THE MARTIN MARIETTA CLEANING METHOD



CHEMICAL AND PHYSICAL CHARACTERISTICS OF CONTAMINATION REMOVAL BASED ON THE MARTIN MARIETTA CLEANING METHOD

CHEMICAL AND PHYSICAL CHARACTERISTICS OF CONTAMINATION REMOVAL BASED ON THE MARTIN MARIETTA CLEANING METHOD



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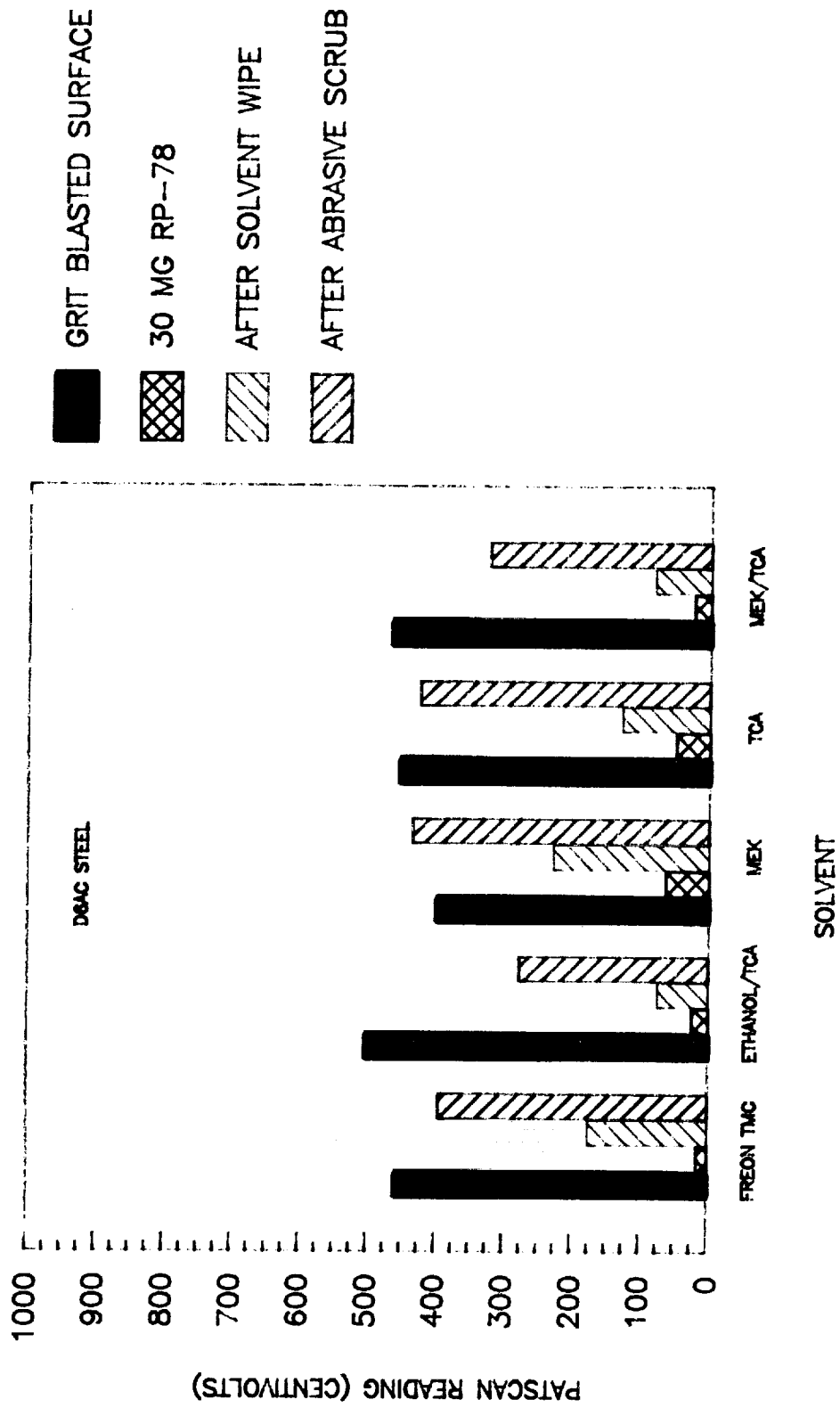
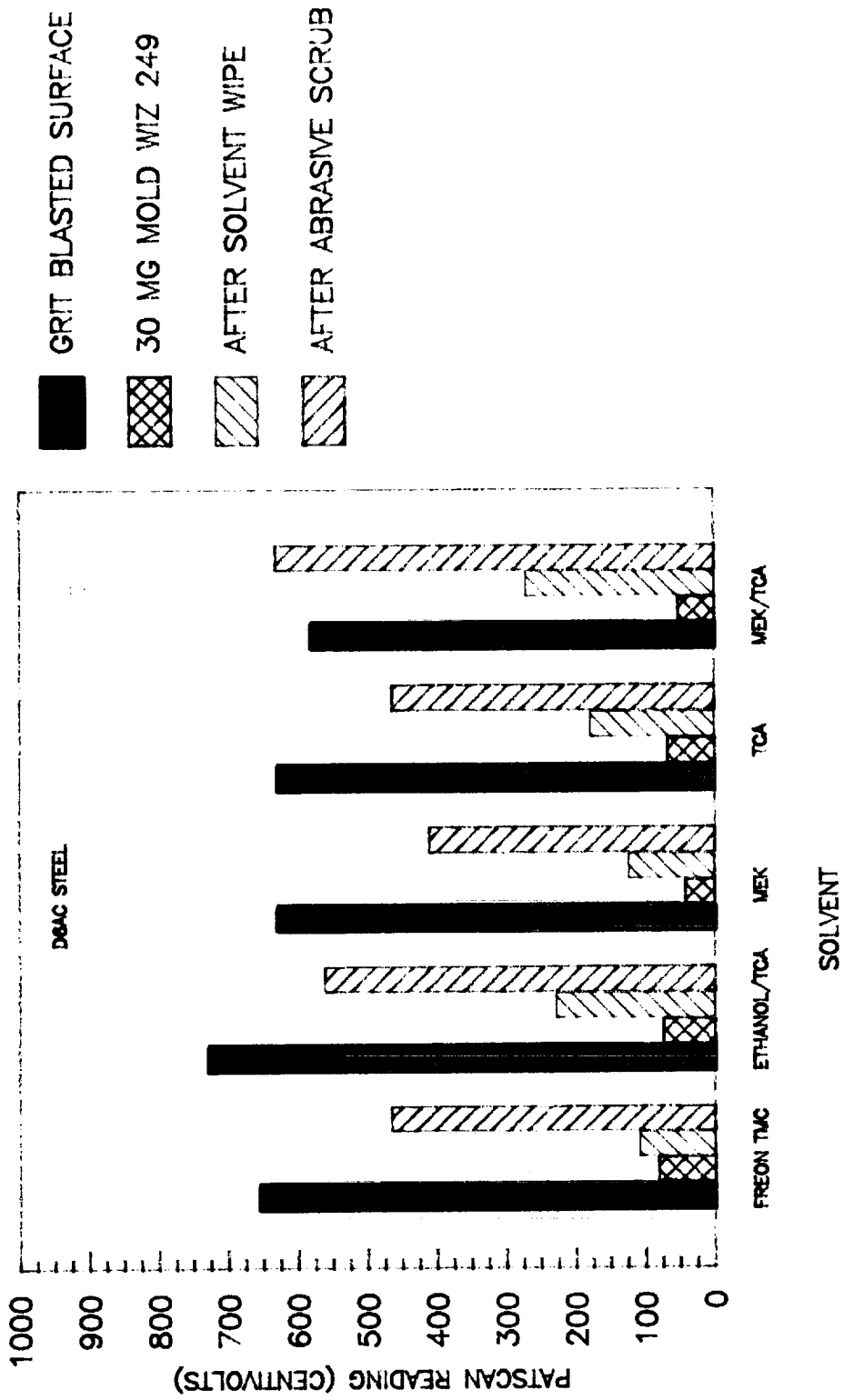
BASED ON THE MARTIN MARIETTA CLEANING METHOD

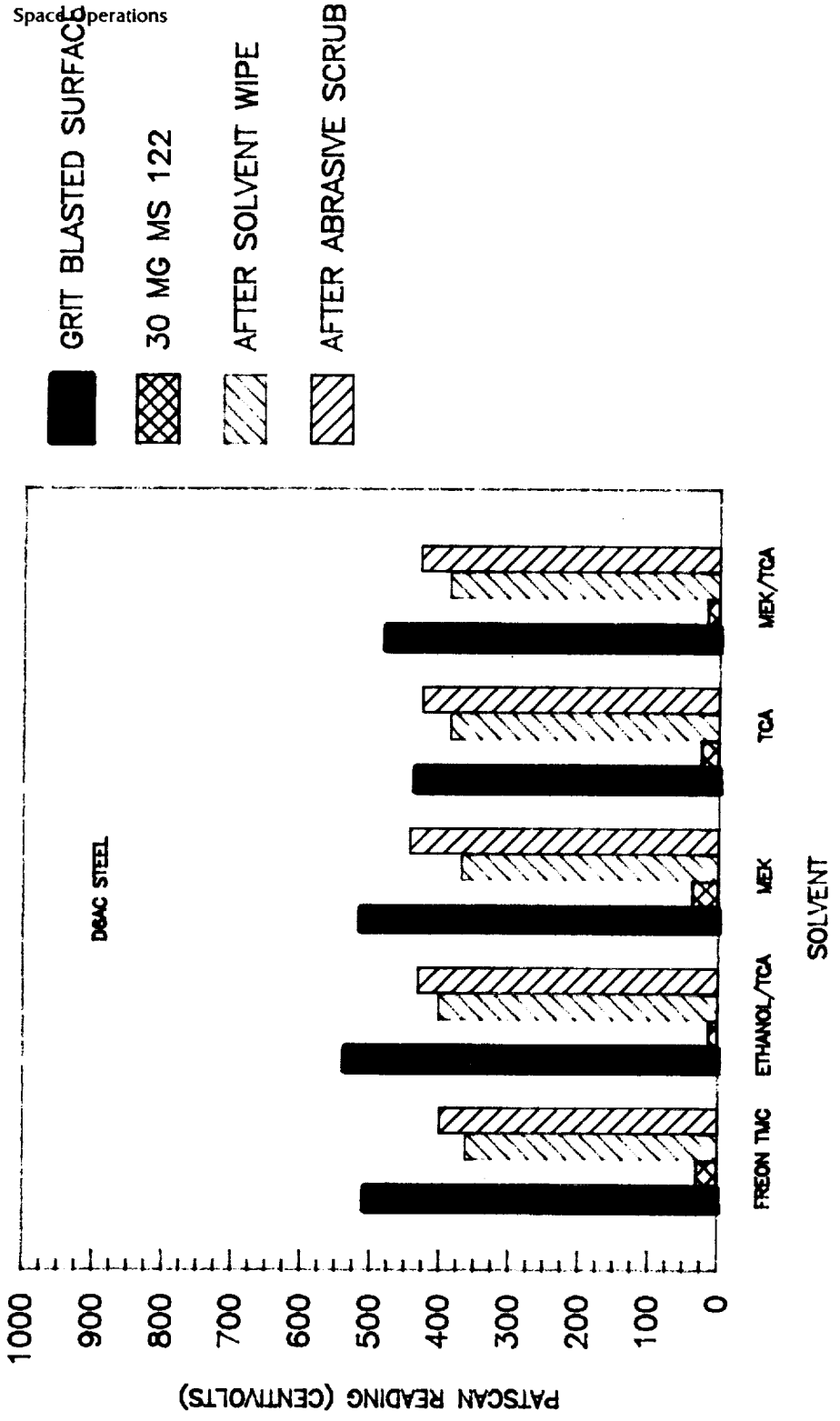


CHEMICAL AND PHYSICAL CHARACTERISTICS OF CONTAMINATION REMOVAL

BASED ON THE MARTIN MARIETTA CLEANING METHOD



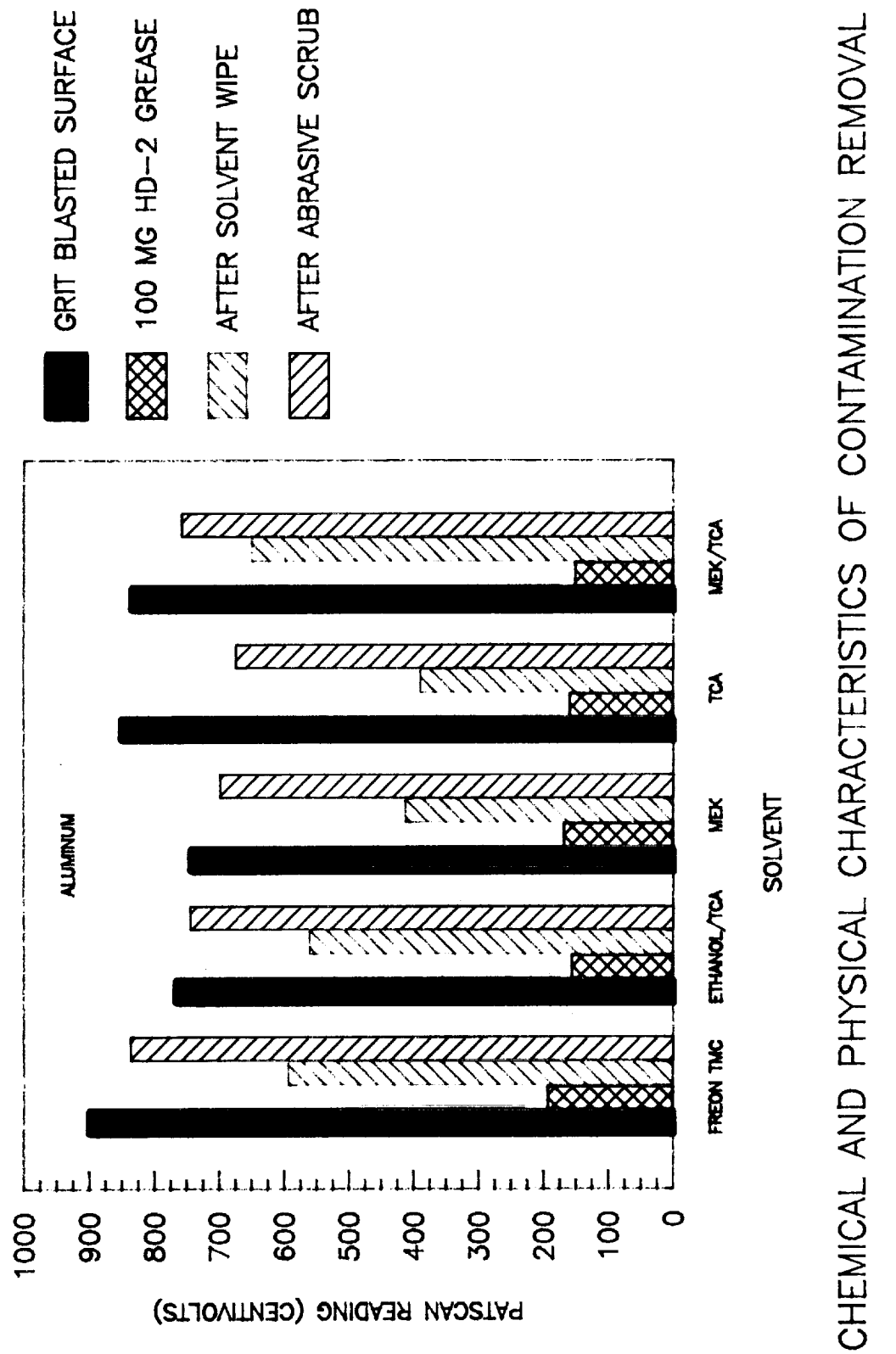
CHEMICAL AND PHYSICAL CHARACTERISTICS OF CONTAMINATION REMOVAL BASED ON THE MARTIN MARIETTA CLEANING METHOD

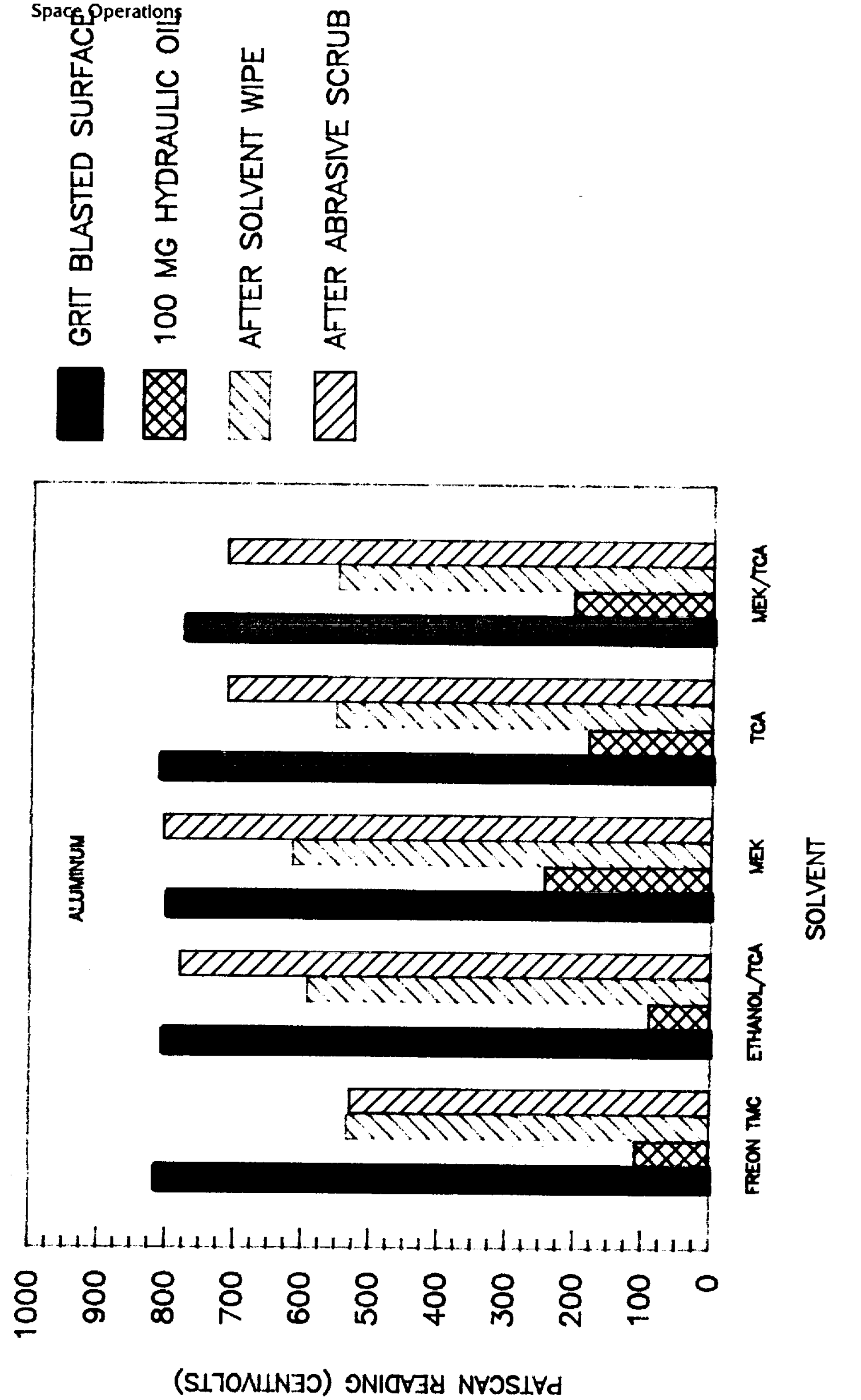


APPENDIX B

MARTIN MARIETTA CLEANING METHOD - ALUMINUM

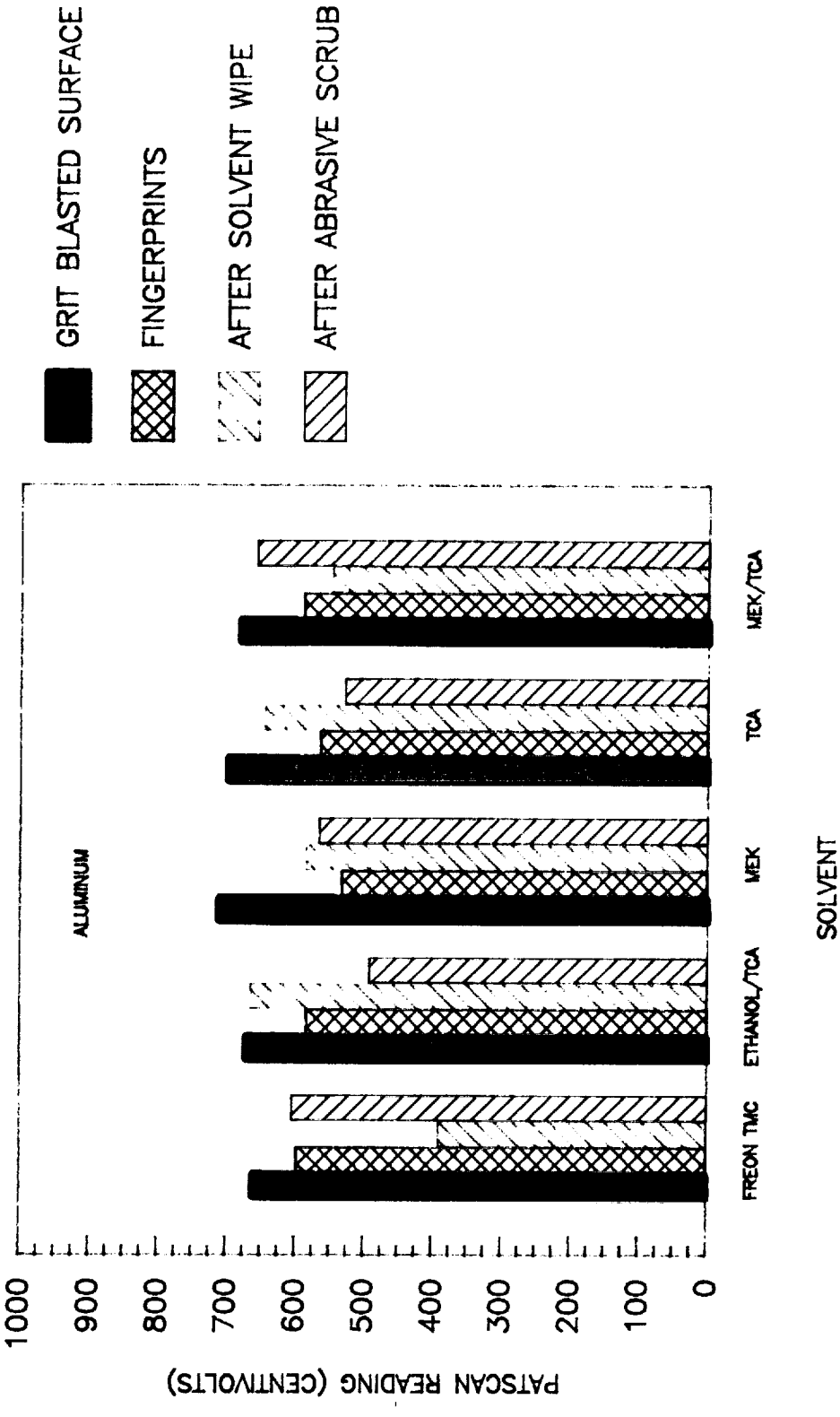
CHEMICAL AND PHYSICAL CHARACTERISTICS OF CONTAMINATION REMOVAL BASED ON THE MARTIN MARIETTA CLEANING METHOD





CHEMICAL AND PHYSICAL CHARACTERISTICS OF CONTAMINATION REMOVAL BASED ON THE MARTIN MARIETTA CLEANING METHOD

CHEMICAL AND PHYSICAL CHARACTERISTICS OF CONTAMINATION REMOVAL BASED ON THE MARTIN MARIETTA CLEANING METHOD



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